DEPARTMENT OF
ECOLOGY
State of Washington

Washington State Department of Ecology
Nuclear Waste Program
Hanford Project

Document Receipt Verification

Date: 10/31/12 ☐ Incoming ☒ Outgoing

To: Alan Ollander

Receiver Signature: ARO

From: Nancy Uziemblo

Document Title and Number:
RPP-22393, Rev. 6A, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

1. Document Title and Number: RPP-22393, Rev. 6A, 241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan		
2. Minor Field Change: (Section 12.4 HFFACO Action Plan) ☐ Yes: (WRPS Signature Only – Attach signed form to Primary Document for record purposes) X No: Proceed to Box 3	3. Document Issue Date: 05/21/12 4. Document Modification Notice Date: 09/05/12	5. Notice Number: 2012-08
6. Do proposed changes require schedule changes? (Would this extend completion of retrieval beyond 12 months from date of initiation?) ☐ Yes X No	7. Do proposed changes include specific additions, deletions, or modification to scope and/or requirements which affect the overall intent of the plan? ☐ Yes X No	8. (Check only one box) ☐ Significant Modification (Check if the answer to question in either section 6 or 7 is "yes". Significant modifications require revision of the primary document.) Minor Modification X Requires modification of the document X Can be accomplished with Modification Notice.

9. Description and Justification of Change:

Change Description: A change is needed to specify that the modified sluicing waste retrieval system for tank C-102 will use an extended reach sluicer (ERSS) with high pressure water capability. The ERSS was shown to be effective for C-112 retrieval operations. High pressure water is enhancing retrieval of C-107. Since high pressure water will be available, the second retrieval technology is being changed from chemical dissolution to high pressure water.

Justifications:

- Abbreviations and Acronyms—Added ERSS
- Section 3.0, pg 3-1—identified ERSS as the modified sluicing tool and changed the C-102 second technology to high pressure water
- Section 3.1.1, pg 3-2—added description of high pressure water purpose
- Section 3.1.3, pg 3-13—added description of ERSS operation
- Section 3.1.3, pg 3-14 and 3-15 —added ERSS to limit of technology discussion
- Section 3.1.4, pg 3-16—Added C-104 to list of tanks using chemical dissolution and deleted C-102
- Section 3.3 pg 3-22 to 3-23—added justification for high pressure water selection as the second technology

See the attached redline strikeout pages.

Office of River Protection, State of Washington Department of Ecology
Tank Waste Retrieval Work Plan/Functions and Requirements Change Notice
(Per Hanford Federal Facility Agreement and Consent Order Section 9.3)

10. Impact of Change:

The change allows the Tank Operations Contractor to use high pressure water as the second retrieval technology for C-102.

11. Additional Requirements and/or Provisions

Approvals

Washington River Protection Solutions, LLC	Office of River Protection	State of Wash., Dept. of Ecology
☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date	☐ Provisional Approval[2] Date
☒ Final Approval Date 10/25/12	☒ Final Approval Date 10/25/12	☐ Final Approval Date

Notes

1 - For use by Ecology to identify any additional information needed to make a decision regarding the request for modifications. In addition, Ecology will identify actions, if any, regarding the modification request that DOE may take pending Ecology's final decision

2 – Provisional approval allows DOE and it's contractors to take specific actions identified in section 11, prior to final approval of this modification.

LIST OF TERMS

Terms

High Pressure Water in the context of this document means any water supplied at a higher pressure than the raw water supply pressure.

Abbreviations and Acronyms

1C	bismuth phosphate first-cycle decontamination
ALARA	as low as reasonably achievable
BBI	best-basis inventory
CH2M HILL	CH2M HILL Hanford Group, Inc.
COPC	constituent of potential concern
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERSS	Extended Reach Sluicing System
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
HI	hazard index
HIHTL	hose-in-hose transfer line
HRR	high-resolution resistivity
IH	Industrial Hygiene
ILCR	incremental lifetime cancer risk
LDM	leak detection and monitoring
ORP	Office of River Protection
PrHA	Process hazards analysis
PUREX	plutonium-uranium extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
RMS	retrieval monitoring system
SST	single-shell tank
TBP	tributyl phosphate
TOC	tank operations contractor
UPR	unplanned release
WMA	waste management area
WRS	waste retrieval system

Units

%	percent
Ci/kg	curies per kilogram
Ci	curie
Ci/L	curies per liter
°F	degrees Fahrenheit
ft	foot
ft^3	cubic feet

3.0 PLANNED WASTE RETRIEVAL TECHNOLOGY

This section provides a description of the primary and secondary waste retrieval technologies for retrieving the waste from tanks C-102, C-104, C-107, C-108, and C-112. The rationale for selection of primary and secondary technologies is provided in Section 3.3. However, in accordance with Appendix C, Part 1 of the Decree:

> "If 360 cubic feet is reached with the first retrieval technology, the first retrieval technology shall be used to the "limits of technology" and a second retrieval technology shall not be required."

The primary technology is the first technology deployed for waste retrieval.

The primary technology for C-102, C-104, C-108, and C-112 will be modified sluicing. For C-102 the modified sluicing will be done with an Extended Reach Sluicer (ERSS). If required to meet the tank residual waste conditions in the Decree, the second technology for ~~C-102,~~ C-104, C-108 or C-112 will be a chemical retrieval process. The second technology for C-102 will be high pressure water deployed with the ERSS. The primary technology for C-107 will be sluicing with supernate or water. The second technology will be high-pressure water spray. Both of these technologies will be deployed via MARS-S. The MARS-S is designed to implement both the primary and secondary technology when needed. Retrieval activities will switch from one technology to the other as required to reach the Consent Decree residual waste goal.

In accordance with the Decree, Appendix C, Part 1:

> "If the waste residual goal of 360 cubic feet is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP shall be deployed to the "limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above [in Appendix C, Part 1 of the Decree]. If DOE and Ecology are unable to reach agreement, the resolution of the issue of whether a third retrieval technology shall be deployed shall be resolved through the dispute resolution process set forth in Section IX of this Decree."

3.1 SYSTEM DESCRIPTION

This section provides a description of the waste retrieval systems (WRS) and how they will be operated. Continued design development and incorporation of lessons learned may lead to changes in the design and/or operating strategy.

3.1.1 Physical System Description

The WRS will consist of a modified sludge sluicing system to mobilize and retrieve waste from tanks C-102, C-104, C-108, and C-112. The sluicing system will consist of two (or more) sluice nozzles and a slurry pump in each tank. The sluice nozzles or hydraulic sluicers will be controlled from a control trailer located near the tanks. The sluice nozzles will be installed in existing tank risers. The sluice nozzles will have the capability to direct liquid at various locations in the tanks. The C-102 WRS will have the capability to use high pressure water to break apart hard agglomerations of waste. The flow rate through the sluice nozzles will be adjusted based on the pump-out rate so that the rate of liquid introduction will approximately equal the rate of solution removal with the objective of minimizing the liquid waste volume in the retrieval tank.

The WRS for tank C-107 will be the Mobile Arm Retrieval System-Sluicing (MARS-S). Standard modified sluicing is maintained as an alternate WRS for C-107 in the event this first deployment of the MARS-S has to be halted. The MARS-S sluicing process consists of an extendable robotic arm suspended from a large central riser added to the tank and serves as the deployment platform for two separate retrieval technologies. The MARS-S is a mobile arm capable of rotating and extending in the tank. The system is equipped with two technologies to mobilize the waste and direct it to a pump for removal. For one technology, the end of the arm is equipped with sluice nozzles that direct supernate and/or water onto the waste surface from a short distance away, and directs the mobilized waste slurry backwards to a slurry pump. A second technology provided by the MARS-S is the addition of high pressure water spray nozzles that serve to break up hard waste agglomerations and direct them to the slurry pump. The slurry pump may use a backstop that can capture the slurry waste and is equipped with more supernate and water nozzles to further break the waste up for removal by the pump.

The waste retrieved from tanks C-102, C-104, C-107, C-108, and C-112 will be transferred to a DST. To minimize the overall volume of waste requiring storage in the DST system, the waste retrieval project plans to use DST supernate as the primary sluice liquid (see Section 3.1.2 for operating description). The WRS will also have the capability to use raw water for sluicing with valving change or minor modifications.

The waste retrieval plan as of October 2010 for using DSTs for waste receipt and as source tanks for supernate recycle is shown in Figure 3-1. The DSTs were selected based on their location, available space, and existing or planned equipment upgrades. Additional detail on the planned use of supernate during waste retrieval is discussed in Section 3.2.

DST to the SST. All waste transfers, including transfer of waste from the C farm tanks to the DSTs and the transfer of supernate from DSTs back to C farm tanks, will be performed using transfer lines that provide secondary containment. The waste retrieval project currently plans to use overground hose-in-hose transfer lines (HIHTLs) and the *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant DST transfer system.

3.1.3 Waste Retrieval System Operating Description

The overall WRS operating strategy will consist of reducing the SST waste inventories. The process will be monitored using closed-circuit television to facilitate waste retrieval and minimize any liquids in the tanks. Supernate will be used as the primary retrieval liquid. Raw water will be used in limited quantities as necessary for waste conveyance and transfer line flushing.

During routine modified sluicing operations, waste retrieval will be initiated by starting the supernate pump in the DST source tank and using the pumped supernate to provide sluicing fluid to the selected sluice nozzle. Initial sluicing will be focused in the center portion of the tank to minimize the time required to get liquid to the slurry pump to allow it to be started. The in-tank camera will be used to provide visual input for directing the sluice nozzle. The slurry pump in tank C-102, C-104, C-108, or C-112 will be started as soon as liquid from the sluicer operation reaches the area of the pump inlet and there is enough liquid present to prime and operate the pump. During waste retrieval, the flow of liquid into the tanks through the sluice nozzles will be controlled to both limit accumulation of liquid in the tank and to maximize waste retrieval efficiency. The slurry removed will consist of both mobilized tank waste and DST supernate used for mobilization. Maintaining a balanced pumping rate into and out of the tanks is integral to minimizing the liquid volume in the tanks and reducing the potential for leakage.

An additional technology provided by the ERSS is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure supernate (or water) stream. High pressure water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

During routine MARS-S operations, waste retrieval is similar to that for modified sluicing, with the exception that the supernate nozzles on the MARS-S will be located near the waste surface. The MARS-S arm will be moved radially and axially to reach all areas of the tank. The slurried waste is directed back to the central pump and removed from the tank. Nozzles located at the pump backstop are used to further break up waste particles. An additional technology provided by the MARS-S is the capability to add high pressure water to break up particles that resist breakup or mobilization with the lower pressure supernate (or water) stream. Water could be used at any time during the retrieval process but it is not envisioned that much will be needed until towards the end of retrieval.

If initial sluicing efforts show that tank C-102, C-104, C-107, C-108, or C-112 sludge is not readily mobilized, it may be necessary to add sufficient liquid to the tank(s) to cover the sludge and allow it to sit for a period of time to soften the solid waste before sluicing is resumed. It is not likely that there will be any need to soften the waste. Tank C-108 waste is estimated in the

BBI to be about 40 wt% water; tank C-102 waste is estimated to be 40 to 65 wt% water; and tanks C-104, C-107, and C-112 waste is estimated to be about 50 wt% water. The only reason to soften the waste would be if the surface had become so hard it resisted breakup by solution from the sluicing nozzles. Extensive dryout of the waste (not likely at the estimated water levels and the 70 to 100 °F waste temperatures) could cause some agglomeration of the material. The waste could also be held together with salt crystals from supernate that had evaporated. Should either of these occur and the waste not breakup effectively when hit with solution from the sluicing nozzles, adding liquid to the waste surface may be tried to soften it for retrieval. Liquid breaks down the bonds in dried out waste or dissolves most salt crystals. The supernate used will not be saturated at the start of retrieval in a tank and thus will be expected to dissolve such salts or break the crystal structure down sufficiently to permit retrieval.

The volume of free liquid added to soften any waste would be minimized by keeping the free liquid height above the waste to as small as practical. Any free liquid added beyond this would provide little benefit. The time period needed to soften the waste is unknown; it is expected to be a few days or longer.

Pumping during sluicing will maintain minimum liquid volume in the tanks. This will be performed by initially directing the nozzle flow towards the center of the tanks. As the sluice liquid contacts the tank waste, the sludge will be mobilized and retrieved via the slurry pumps. Typically, one sluicer will be operated at a time operating at a flow rate of approximately 60 to 120 gal/min.

During all field activities, standard operating procedures and safety precautions will be implemented to protect worker health and safety, the public, and the environment. In accordance with standard operating procedures, health physics and industrial health technicians will monitor conditions within the tank farm in accordance with approved monitoring plans.

When the level of residual solids gets low in the tank, the volume of solids removed per unit volume of sluicing fluid removed from the tank will be tracked. The units used will be selected by engineering personnel. Waste retrieval operations will continue in an effort to obtain the goal of 360 ft^3 or less of residual waste remains in the tank, and/or the limits of technology have been reached for this retrieval method. The project will determine when a tank retrieval is complete by following the Consent Decree requirements stating "that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with the consideration of practicability to include matters such as risk reduction, facilitating tank closures, cost, the potential for exacerbating leaks, worker safety and the overall impact on the tank waste retrieval and treatment mission."

Until a risk evaluation is available, the limit of technology for modified sluicing is defined in RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing* as when the concentration of SST waste in the retrieved slurry sent to the DST is within, or bracketing, the range of 0 to 0.6 volume percent.

There is no limit of technology definition for an ERSS or MARS-S waste retrieval process. A limit of technology definition will not be developed until sufficient ERSS and MARS-S retrieval

operations have been performed to enable development of a justifiable definition. Until an ERSS MARS-S limit of technology definition is developed the same value used for modified sluicing in RPP-50910 is applied to MARS-S retrieval operations.

There is no limit of technology definition for a chemical retrieval process. A limit of technology definition will not be developed until sufficient chemical heel retrieval operations have been performed to enable development of a justifiable definition. It is estimated that this will take 3 to 4 heel retrieval operations.

Appendix C, Part 1 of the Decree defines the limit of technology as follows:

> "The "limits of technology" means that the recovery rate of that retrieval technology for that tank is, or has become, limited to such an extent that it extends the retrieval duration to the point at which continued operation of the retrieval technology is not practicable, with consideration of practicability to include matters such as risk reduction, facilitating tank closures, costs, the potential for exacerbating leaks, worker safety, and the overall impact on the tank waste retrieval and treatment missions."

For MARS-S, data for retrieval performance measurement used to show the limits of technology have been met will be used after implementation of one or both low pressure sluicing and high pressure water operations (each technology will not be evaluated separately for its limit of technology).

Ecology is notified in the Tri-Party Agreement project manager's monthly meeting when the limits of technology have been reached. Status reports are continued until waste retrieval operations cease. An SST waste retrieval evaluation form and a retrieval report are then prepared and issued and in accordance with the Decree, Part IV, B. 5:

> "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank. For purposes of this Consent Decree, "complete retrieval" means the retrieval of tank waste in accordance with Part 1 of Appendix C and with the retrieval technology/systems that were established by Part 1 of the TWRWP either by approval of Ecology or after dispute resolution by the Court under Section IX of the Decree."

Following completion of waste retrieval and final tank flushing, the residual waste volume will be determined using the methodology defined in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives*, and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure.*

3.1.4 Chemical Retrieval Process

Chemical retrieval process details are contained in the process control plan for each tank using a chemical retrieval process. When samples are available the retrieval process is tested on samples of tank waste. If hard heel samples are not obtained the hard heel composition is deduced from

tank historical data. The hard heel volume to be treated is normally not known until sluicing retrieval is complete. The hard heel volume can be determined from visual observation, level sensors, or liquid displacement using tank level sensors. The composition and volume of the heel are used to determine the quantity and type of chemicals used for chemical retrieval process.

The chemical retrieval process may be a series of steps or a single action depending on how the waste reacts to the process. If a single step will dissolve sufficient solids to achieve the volume reduction mandated by the Decree, only one chemical retrieval process step will be deployed. The chemical retrieval process may include one or more of the following:

- water to remove compounds insoluble in the caustic liquids found in the tanks,
- high molarity caustic solution to break down aluminum hydroxide compounds, or
- other chemicals to aid the retrieval of sludge.

Ecology will be informed of the pre-retrieval estimated volume of liquid(s) to be added to the tank prior to the initial addition(s). Water additions for dissolution and volume reduction associated with a chemical retrieval process are separate actions from the heel rinse described in section 3.2.

Unlike modified sluicing, there is no operational data available that can be used to estimate the recovery rate for a limit of technology determination for a chemical retrieval process planned for ~~C-102, C-104,~~ C-108, or C-112. If the first step of a multiple step dissolution achieves the Decree volume target the limit of technology will be considered to have been met for the chemical retrieval process technology. Using unnecessary chemical retrieval process steps adds risk to worker safety and has retrieval schedule impacts, DST storage volume impacts, and thus possible mission impacts.

If the Decree target volume is not achieved, and all steps of the chemical retrieval process have been deployed as specified in the process control plan, the limit of technology will be considered to have been met for the chemical retrieval process provided the data shows that additional chemical retrieval process steps are not practicable.

Consideration for additional waste retrieval actions will be according to the Decree Appendix C, Part 1 as noted in section 3.0.

3.2 LIQUID ADDITIONS DURING WASTE RETRIEVAL

Supernate from DST AN-101, AN-106, or AZ-101 will be introduced to tanks C-102, C-104, C-107, C-108, and C-112 to mobilize sludge. Supernate will be added at a rate of approximately 60 (or less) to 120 gal/min. The retrieval liquid, along with tank solids, will be removed from these tanks at approximately the same rate. Utilizing recycled supernate to retrieve the waste from the tanks will minimize the overall volume of waste generated during the waste retrieval process. The modified sludge sluicing process will minimize the volume of liquid in the SST during waste retrieval operations.

The use of supernate will be limited by the following:

to sound tanks as identified in HNF-EP-0182 using the modified sluicing or MARS-S systems is acceptable. The mobile retrieval system uses vacuum to remove waste to the tank farm surface where liquid is added to enable the waste to be transferred as a slurry. Because of this difference, the mobile retrieval system or the MARS vacuum system (not described in this document) are currently the preferred waste retrieval technologies for known or suspected leaking tanks.

When modified sluicing or MARS-S sluicing are performed using DST supernate, the overall volume of waste requiring management (storage and/or volume reduction) in the DST system is reduced.

Modified sluicing is a proven technology that has been successfully demonstrated. The only volume added to the DST system is the volume of sludge removed from the SST, plus the water used for line flushes or other uses. There is no deployed process that is more effective.

The MARS-S sluicing system is expected to be an improvement over modified sluicing because it is believed capable of reducing the residual waste volume in a tank to below the Consent Decree limit without requiring an additional technology. The MARS-S enables close access to almost all of the waste in a tank to improve waste mobilization over that of modified sluicing. The first deployment of the MARS-S sluicing system will demonstrate the system capabilities, as well as provide time for making improvements if necessary prior to further deployment. After considering both candidate waste retrieval technologies and designation of the tanks as being sound, modified sluicing using recycled DST supernate was selected as the primary technology for deployment in tanks C-102, C-104, C-108, and C-112. The MARS-S sluicing system is selected for deployment on C-107. This will be the initial deployment for the MARS-S system. The operating experience will provide information for future deployment of the system.

The second technology alternatives, if necessary, should one be required for residual waste removal following modified sluicing, are an in-tank vehicle, high pressure water, and a chemical retrieval process.

Generally, an in-tank vehicle is desirable for large or monolithic particles since it can break these up for sluicing, while a chemical retrieval of larger aggregates may be slow or ineffective due to the small surface area for dissolution. An High pressure water or an in-tank vehicle is preferred as the heel volume increases because a chemical retrieval process may take up too much DST space and, for caustic or acid dissolutions, will have proportionally more impact to the DST space. A chemical retrieval process is preferable for heels where the volume is relatively low so the impact on DST space and the WTP throughput volume is less. A chemical retrieval process may also be preferable if the particles are small because the surface area for dissolution is greater and an in-tank vehicle may just push the fine particles around the tank.

A chemical retrieval process was selected as the second technology for C-104 and C-108 as it can be deployed in less time than an in-tank vehicle and because it is believed the estimated residual heel volume could be chemically reduced to below 360 ft^3 without causing a significant impact to the available DST space or the WTP throughput volume.

A chemical retrieval process was selected as the second technology for ~~C-102 and~~ C-112 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.

High pressure water was selected as the second technology for C-102 as it can be deployed in less time than an in-tank vehicle when the primary technology is no longer effective and the tank residual waste volume in the Decree is exceeded.

Second technology selection inherently relies on past experience and assumptions on the tank waste characteristics that will be present after the first technology is deployed to its limits. If new data is obtained that shows chemical retrieval is not the preferred second technology for tanks C-104, C-108, C-102, and C-112 a TWRWP modification will be made to seek approval for the preferred technology.

The primary and second technologies selected are anticipated to provide the best methods to achieve the 360 cubic feet target volume goal specified in the Decree, when deployed to their "limits of technology." The "limits of technology" as defined in the Decree is noted in section 3.1.3.

3.4 ANTICIPATED PERFORMANCE GOALS

The retrieval technology equipment selected for tanks C-102, C-104, C-107, C-108, and C-112 will be designed, operated, and deployed to each of their limits of technology, as defined in this document, in an effort to obtain a waste residue goal of 360 cubic feet of waste or less for each tank in accordance with the Decree (see Table 3-2).

3.5 WASTE RETRIEVAL SYSTEM DIAGRAM

A preliminary diagram of the modified sluicing WRS in-tank components is provided in Figures 3-3 and 3-4. A preliminary diagram of the MARS-S sluicing WRS is provided in Figure 3-5. As noted in Section 3.1.1, the elevation in the AN tank farm is approximately 22 ft higher than the elevation in the C tank farm and the elevation in the AZ tank farm is approximately 25 ft higher than the elevation in the C tank farm.

3.6 WASTE RETRIEVAL SYSTEM FUNCTIONS AND REQUIREMENTS

This section defines the upper-level functions and corresponding requirements to which the tanks C-102, C-104, C-107, C-108, and C-112 WRSs must be designed and operated. This work plan is not a system specification that defines design criteria for the WRSs. However, the system specification for the tanks WRSs will be consistent with this work plan. The functions and requirements are provided in Table 3-3 and are focused on defining the upper-level requirements for the tanks.